RECRUITMENT GRADATION IN SEMG AS A BASIS FOR TESTING THE FATIGABILITY OF THE MUSCLES

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Abstract **The aim of the study is to find the possibilities to use the surface EMG for estimation of functional state and tiredness of muscles. For that purpose a new analyzing method is proposed.**
It is demonstrated that the coefficient of recruitment (CR) can be used for characterization of the functional state and tiredness of different muscles. CR may be simple and useful parameter for assessment of rehabilitation treatment.

Keywords **– Surface EMG, isometric contraction, functional state of the muscles -tiredness**

I. INTRODUCTION

Electromyography (EMG) is the method for investigating the functional state (FS) of neuromuscular system.

EMG with surface electrodes (SEMG) can be used diagnostically as biofeedback in rehabilitation studies. EMG is based on a functional or so called motor unit i.e. motoneurone with its innervated myofibbers. Power of EMG depends on the frequency of functioning motor units [1].

The differences of the motor units are bound up with the size of the motoneurones, their functional characters as well as the different number and type of myofibbers. Every motor unit has a proper frequency response, which depends on a stimulation of the motoneurone. During maximum contractions of muscles motor units start work synchronously, during the fatigue the decrease of frequencies of the biopotentials can be noticed in the surface EMG. Merletti R. et. al. have concluded that the spectral variables are more sensitive to fatigue than conduction velocity and the average rectified value is more sensitive to fatigue than the root mean square (RMS) value [2]. Arendt-Nielsen L. and Mills LP claimed that their results confirmed the linearity between mean power frequency and fibre velocity and the de- and recruitment of fibbers and changes in motor unit firing rates contribute to the fall in mean power frequency during fatigue [3].

Recruitment is the number of the motor units that become active during the process of contraction. It is achieved by increasing the excitatory synaptic input to the motor neurons. The greater number of active motor neurons and motor units recruitment is the basis for the muscle tension. The smallest motor neurons are part of the slow-oxidative units (S), these motor units are recruited first, followed by fast-oxidative motor units (FR) and finally during very strong contractions, by the fast glycolytic motor units (FF) – Figure 1. The nerve control of whole-muscle tension involves all three types of units. It also means that in the recruitment process and during development of tiredness of muscles all the three types of the muscle fibbers are involved [4].

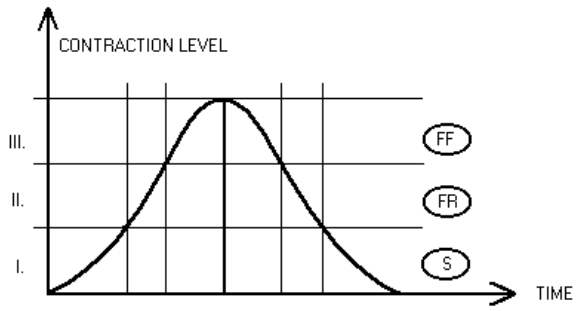

Figure 1. The schematic diagram of the development of the process of contraction and tiredness

The characteristics of muscle contraction depend on
a) Single muscle fibbers
- action potential frequency (frequency-tension relation)
- fibber length (length-tension relation)
- fibber diameter
- functional state of muscles and fatigue.
b) Whole muscle
- tension development by each active fibber
- number of active fibber
- number of fibbers per motor units
- number of active motor units

Total muscle tension depends on the number of fibbers in each motor unit and the number of active motor units [5].

The aim of the study was to investigate the possibilities to use the surface EMG for estimation of functional state and tiredness of muscles by analyzing the presents of high and low oscillations in EMG pattern.

II. MATERIALS AND METHODS

EMG recording and analyzing software was developed on the basis of National Instruments programming environment LabVIEW. The principle of the interference-EMG analysis software is that the peaks of the signal are divided into two groups in time domain - so called medium oscillations and large oscillations. In our case the oscillations were considered to be medium in case their amplitude was 40-100uV, and the large oscillations had an amplitude above 100uV.

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Abstract

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The software finds out how the biolelctrical activity of the medium and large oscillations changes in time.

The software also calculates the ratio of the large and medium oscillation activity, which characterizes the rank of motor unit synchronization.

For the investigation of tiredness of the muscles (m. biceps brachii) we registered the EMG with the surface electrodes by isometric contraction on the 3 levels (30^o, 60^o and 90^o) and by maximum contraction during 2 minutes (EMG before and after contraction). The recordings are made during the first and last four seconds of the contraction. Between every contraction there were also pauses with a duration of 2 minutes. Analyzing software calculated the data of the amplitudes, frequencies and bioelectric activities of "large" and "medium" oscillations in all levels of isometric contraction before and after this.

For analogue EMG registration a measurement device Medicor was used. National Instruments data acquisition board AT-M10-16E-10 was used for A/D conversion with the sampling rate of 5kHz and resolution 12 bits.

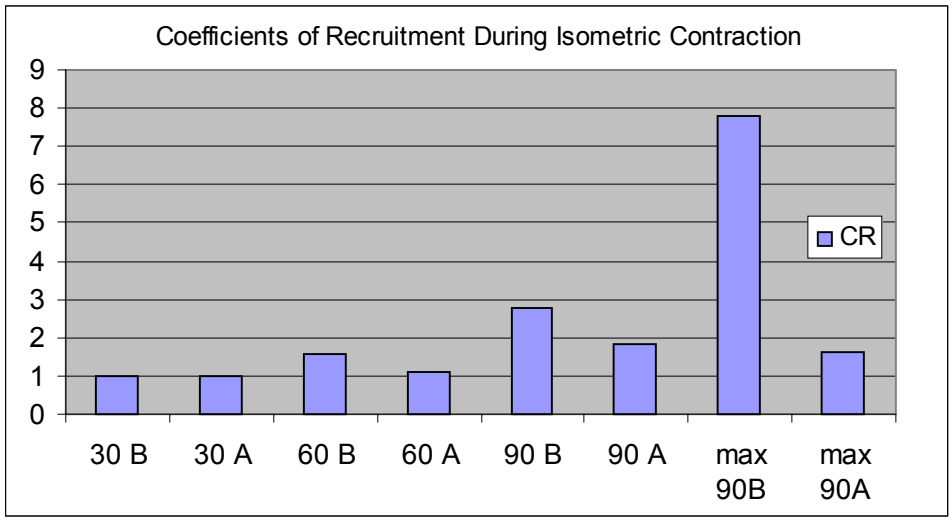

Figure 2. Recruitment coefficients of isometric contraction. The numbers 30, 60 etc present graduation and the letters stand for the phase of the contraction - beginning (B) and after two minutes (A).

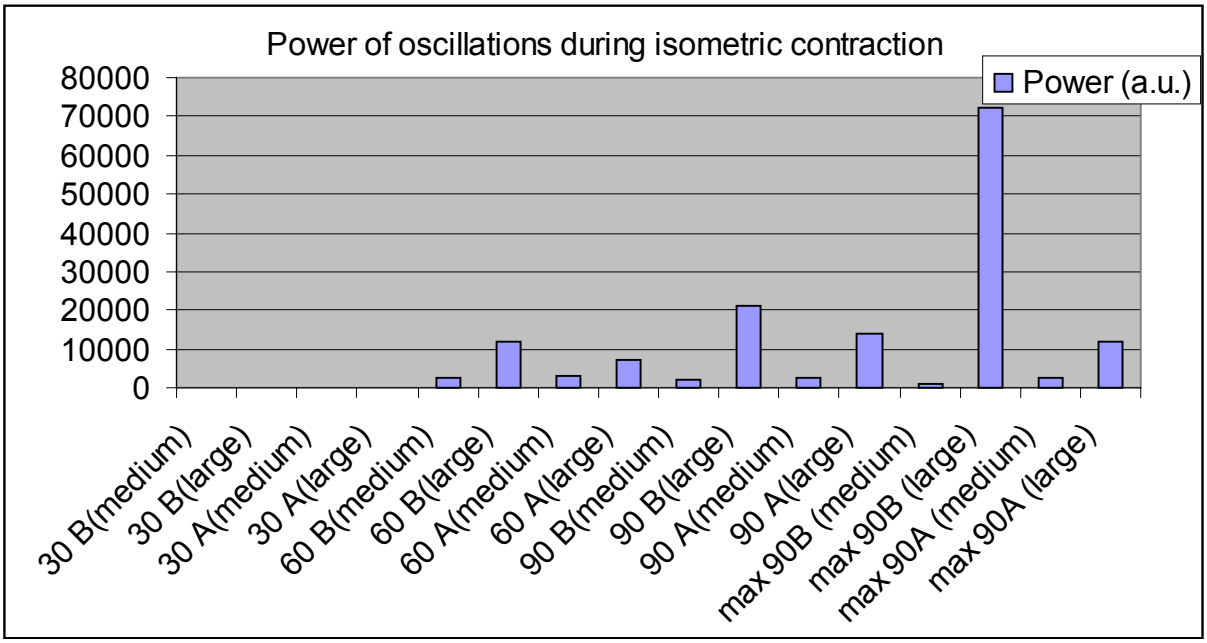

Figure 3. Power of oscillations during isometric contraction. The numbers 30, 60 etc present graduation and the letters stand for the phase of the contraction - beginning (B) and after two minutes (A).

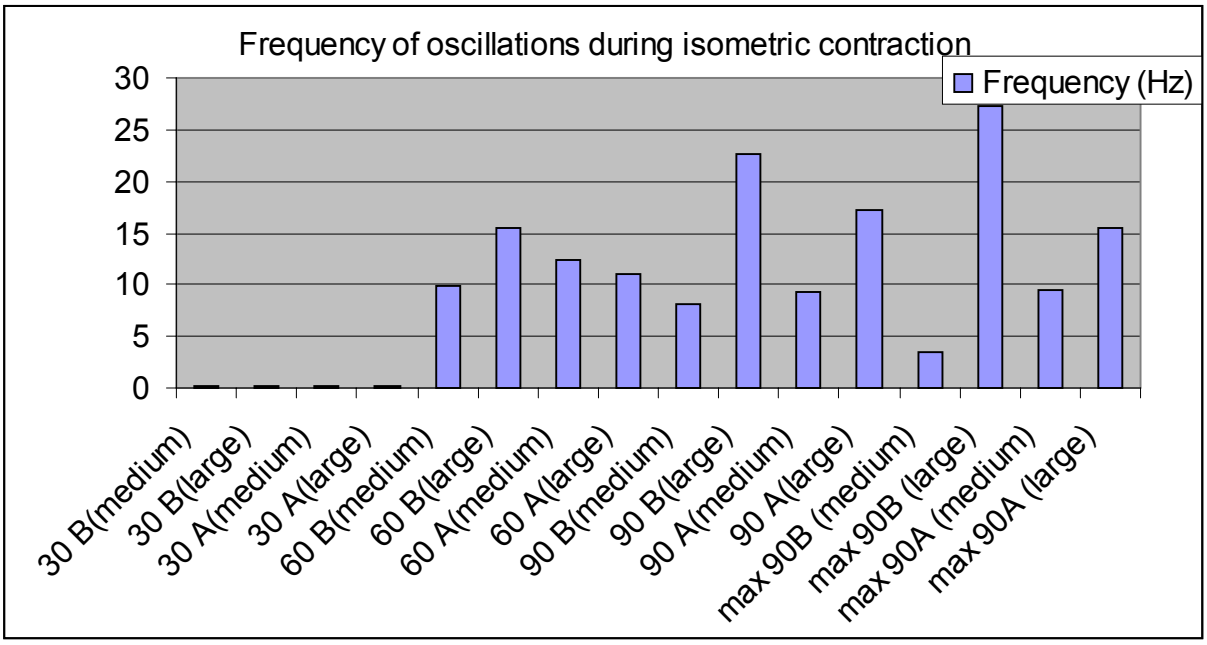

Figure 4. Frequency of oscillations during isometric contraction. The numbers 30, 60 etc present graduation and the letters stand for the phase of the contraction - beginning (B) and after two minutes (A).

III. Results

The results of a recording of a 21 year old healthy female person are presented in Figure 2,3 and 4. Figure 2 represents the coefficients of recruitment during isometric contraction. Figure 3 represents the corresponding power and figure 4 the frequency of occurrence of large and medium oscillations.

IV. Discussion and Conclusions

The conclusions of the study are:

- the using of recruitment data by the registration EMG with the surface electrodes of isometric contraction on the different muscles can be a basics for the investigations of tiredness and functional state during rehabilitation treatment
- so called medium oscillations data characterize the slow – twitch (posture) motor units functional state
- coefficient of recruitment (CR) can characterize the functional state and tiredness of different muscles and this parameter can be helpful to assess rehabilitation treatments.

Acknowledgements

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